MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

ETM3136 – DIGITAL COMMUNICATIONS

(TE)

12 OCTOBER 2019
09:00 a.m – 11:00 a.m
(2 Hours)

INSTRUCTION TO STUDENT

1. This question paper consists of 7 pages with **4** Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

A Pulse Code Modulation (PCM) is used to transmit simultaneously five telemetry signals, $m_i(t)$, $i = 1, 2...5$, each of bandwidth 8 kHz. Consider that maximum tolerable error in sample amplitude of the first signal $m_1(t)$, is 0.2% of the peak amplitude; and for other signals, it's 0.1% of the peak amplitude. The first signal is sampled at 25% over the Nyquist rate and the others at 50% over Nyquist rate.

(a) If the framing and synchronizing require an additional 1% extra bits of the total data rate, find the following

(i) The minimum transmit data rate.
(ii) The minimum bandwidth required to transmit the composite signal by 8-level PAM signalling.

[15+5 marks]

(b) If the five signals multiplexed by time division multiplexing technique (TDM) with frame period 8.68μs, consider the bit rate of the TDM output is the same data rate you calculated in (a). How many synchronization bits were added? How many bits does TDM pick per user? [5 marks]

Continued...

Question 2

(a) Figure Q2 shows a digitally modulated signal $x(t)$. All possible symbols are shown, and T_{sym} denotes the symbol duration.

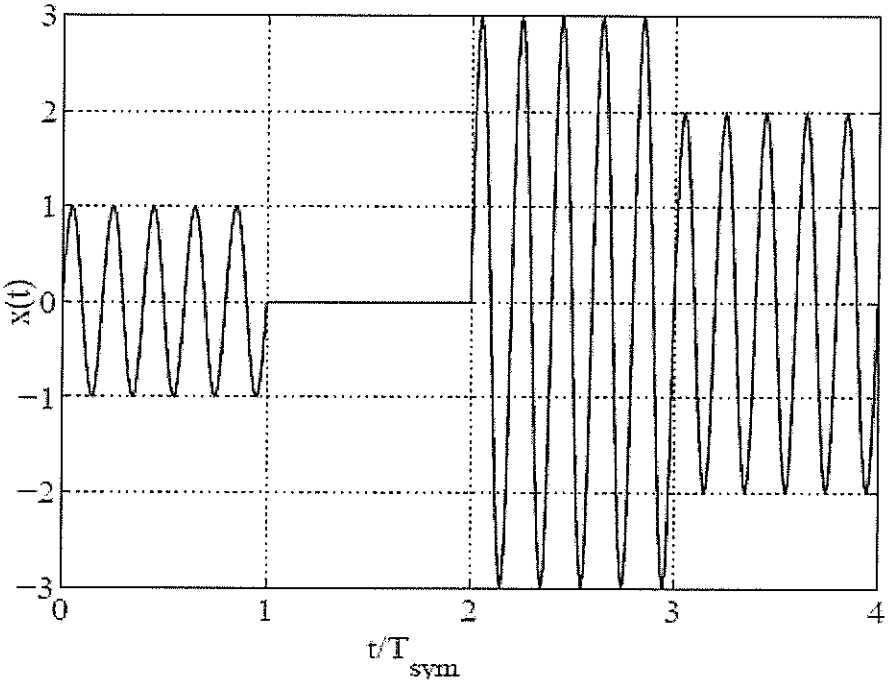


Figure Q2

(i) What type of modulation used to modulate the signal $x(t)$?
(ii) What is the number of levels (i.e., l) of the modulation?
(iii) Sketch the phase diagram qualitatively (i.e., constellation diagram).
(iv) Which time t_1 is needed for the transmission of 8000 bits? Assume that symbol period, $T_{sym} = 3$ms.

[2+2+2+3 marks]

(b) A voice band telephone channel passes the frequencies in the band from 500Hz to 11000Hz. It's desired to design a modem that transmit at a symbol rate of 10606 symbols/s, with the objective of achieving 52500bits/s. select an appropriate QAM signal constellation, carrier frequency, and the roll-off factor of a pulse with a raised cosine spectrum that utilizes the entire frequency band. Sketch the spectrum of the transmitted signal pulse and indicate the carrier frequency, low and high frequencies.

[13 marks]

(c) A frequency hopping (FH) binary orthogonal frequency shift keying system employs an $m = 5$ stage linear feedback shift register that generates a maximal-length sequence. Each state of the shift register selects one of L non-overlapping frequency bands in the hopping pattern. The bit rate is 100 bit per second and the hop rate is once per bit. Determine the hopping bandwidth for this channel. [3 marks]

Continued...

Question 3

(a) Consider a code division multiple access (CDMA) system accommodates 30 equal-power users. Each user transmits information at 5kbits/s with a direct-sequence spread-spectrum BPSK modulation signal. Calculate the minimum chip rate of the PN code in order to maintain a bit error probability of 10^{-5}. Assume that the receiver noise is negligible with respect to the interference from the other users.

[10 marks]

(b) Binary PSK (BPSK) is used for data transmission over an AWGN channel with power spectral density $N_0 = 10^{-10}$ W/Hz. The transmitted signal energy is E_b, with bit rate 10 Kbit/s and signal amplitude (A=3.35mV).

(i) Determine the error probability of 10^{-6} when the data rate is 10 Kbps, 100 Kbps and 1Mbps.

(ii) Why is it that, when you increase the data rate of a communications system, typically, the error rate increases?

[10+5 marks]

Continued...

Question 4

(a) A three-stage switching structure is to accommodate N=20 input and 20 output terminals. There are 5 first stage and third stage matrices and 2 intermediate switches.

(i) Sketch the three-stage switching, label all the switches.

(ii) What is the maximum number of connections that can be supported at any given time? Repeat for 10 intermediate switches.

(iii) Assume that in the multistage switch, an input line is busy 20% of the time. Estimate the percent of time p that a line between the first and second stage is busy, assume that only 3 intermediate switches.

(iv) If the structure is to be non-blocking how many crosspoints are required?

[5+4+4+4 marks]

(b) Faculty of engineering (FET) used to offer 30 calls between 10:00am to 12:00pm with an average call 5 minutes and loss 3 calls. Find

(i) The traffic offered.
(ii) The traffic carried.
(iii) The traffic lost.
(iv) The grade of service.

[8 marks]

End of Page

Appendix I

Tabulated values of Q-function

The Q Function (Gaussian Distribution with $\mu = 0$ and $\sigma = 1$)

$$Q(a) = \int_a^\infty \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}}\, dx \qquad Q(a) \cong \frac{1}{a\sqrt{2\pi}} e^{\frac{-a^2}{2}} \text{ for } a \geq 3$$

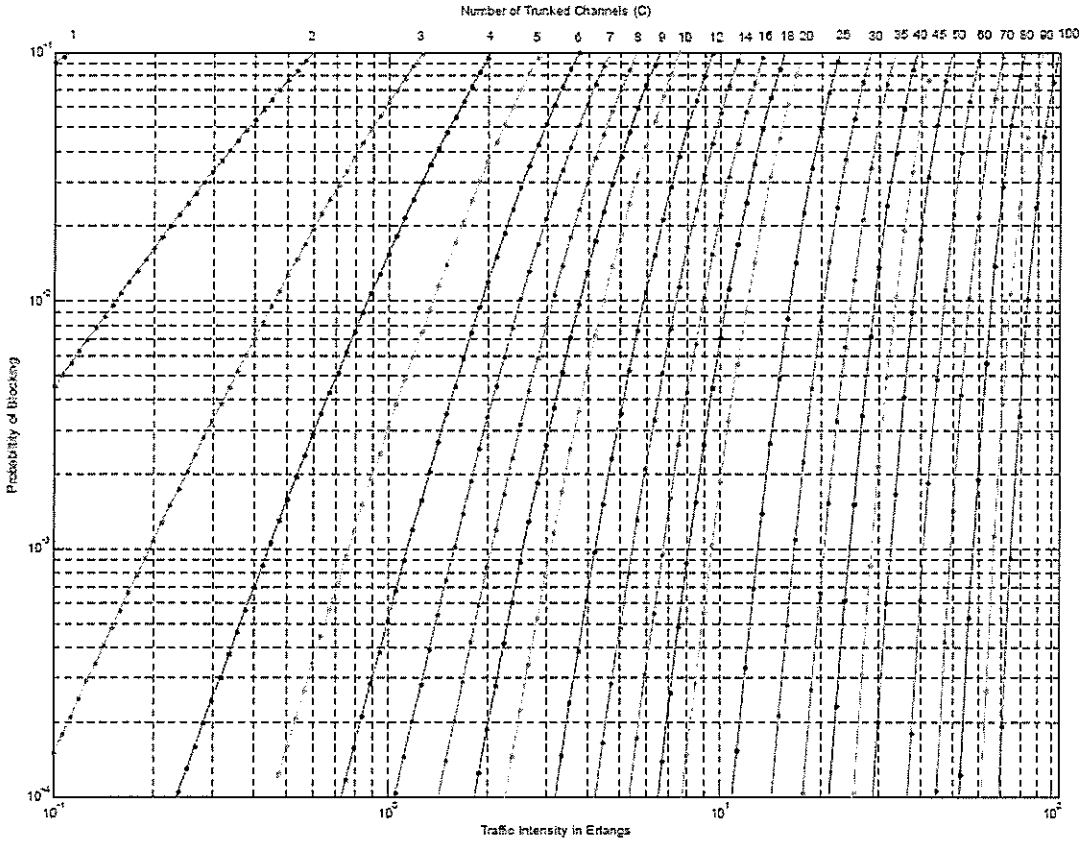
	3rd Significant Digit									
a	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$Q(a)$	a
10^{-4}	3.73
5×10^{-5}	3.90
10^{-5}	4.27
5×10^{-6}	4.43

$Q(a)$	a
10^{-6}	4.76
10^{-7}	5.20
10^{-8}	5.61
10^{-9}	6.00

Appendix II

Probability of Call Blocking in an Erlang B System


Number of Trunked Channels (C)
1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 25 30 35 40 45 50 60 70 80 90 100
Probability of Blocking
Traffic Intensity in Erlangs

$$B = \frac{R_s}{2}(1+r)$$

$$P_e)_{BPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

$$PG = \frac{R_c}{R_b}$$

$$\frac{E_b}{N_0} = \frac{PG}{J/P} = \frac{\frac{R_c}{R_b}}{J/P}$$

$$C = k\left[2N + (N/n)^2\right]$$